A¹ 7

Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 523 702 A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: 92112176.0

(22) Date of filing: 16.07.92

(51) Int. Cl.5: H01J 31/12

(30) Priority: 17.07.91 JP 201162/91

(43) Date of publication of application: 20.01.93 Bulletin 93/03

(84) Designated Contracting States: AT BE CH DE DK ES FR GB GR IT LI LU NL PT SE

(71) Applicant: CANON KABUSHIKI KAISHA
30-2, 3-chome, Shimomaruko, Ohta-ku
Tokyo(JP)

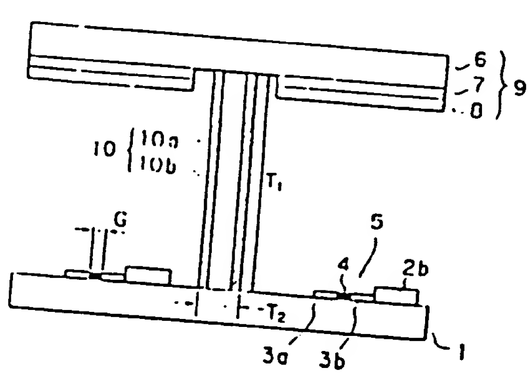
(72) Inventor: Nomura, Ichiro, c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko
Ohta-ku, Tokyo 146(JP)
Inventor: Suzuki, Hidetoshi, c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko
Ohta-ku, Tokyo 146(JP)
Inventor: Kaneko, Tetsuya, c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko
Ohta-ku, Tokyo 146(JP)
Inventor: Mishina, Shinya, c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko
Ohta-ku, Tokyo 146(JP)
Inventor: Nakamura, Naoto, c/o Canon Kabushiki Kaisha
30-2, 3-chome, Shimomaruko
Ohta-ku, Tokyo 146(JP)

(74) Representative: Tiedtke, Harro, Dipl.-Ing. et al
Patentanwälte Tiedtke-Bühling- Kinne & Partner Bavariaring 4 Postfach 20 24 03
W-8000 München 2(DE)

(54) ## Image-forming device.

(57) An image-forming device having, in an envelope, an electron-emitting element (5), an image-forming member (8) for forming an image by irradiation of an electron beam emitted from the electron-emitting element (5), and an electroconductive supporting member (10) for supporting the envelope (internally), comprises a means for controlling the potential (13) of the supporting member (10) to be not higher than the maximum potential applied to the electron-emitting element (5). The electron-emitting element (5) and the image-forming member (8) can be placed in juxtaposition on the same substrate (1), an electroconductive substrate (6) can be additionally provided in opposition to the face of the substrate, and the supporting member (10) can be connected electrically to one of said electrodes (2,3) and also to the electroconductive substrate (1).

FIG. 2



BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an image-forming device employing electron-emitting elements.

Related Background Art

Hitherto thin plate-type image-forming devices have been used, in which a plurality of electron-emitting elements are arranged in a plane and are counterposed to an image-forming members for forming image by electron beam irradiation (a member which emits light, changes its color, become electrified, or denaturated by collision of electrons, e.g., a fluorescent material, and a resist material). Figs. 35 and 36 show outline of construction of a conventional electron beam display device as an example of the image-forming device. Fig. 36 shows a sectional view at A-A' in Fig. 35.

The construction of the conventional electron-beam display device shown in Figs. 35 and 36 is described below in detail. A rear plate 101, an external frame 111, and a face plate 109 constitute an envolope. The interior of the envelope is maintained vacuum. Electrodes 103a and 103b, and an electron-emitting section 104 constitute an electron-emitting element 105. A scanning electrode 102a and an information signal electrode 102b are wiring electrodes, and are connected respectively to the electrodes 103a and 103b. A glass substrate 106, a transparent electrode 107, and a fluorescent material (an image-forming member) 108 constitute the face plate 109. The numeral 112 indicates a luminescent spot, and the numeral 110 indicates a supporting member for supporting the envelope against the atmospheric pressure. The electron-beam display device displays an image by application of signal voltages between scanning electrodes 102a and information signal electrodes 102b arranged in an X-Y matrix to project an electron beam onto the fluorescent material 108 in correspondence with information signals. As the electron-emitting element 105, useful are thermoelectron-emitting elements in which electrons are emitted from the electron-emitting section 104 on heating; field emission elements disclosed in U.S. Patent No. 3,755,704 and U.S. Patent No. 4,904,895; and surface conduction type emitting elements disclosed in U.S. Patent No. 5,066,883.

In the above-described plane type electron beam display device, the inside of the envelope is kept at a vacuum. A supporting member 110 is provided between the rear plate 101 and the face plate 109 as shown in Fig. 36 to support the envelope internally against the external atmospheric pressure. The supporting member 110 is usually made of an insulating material to give dielectric strength against high voltage applied between the fluorescent material 108 (or the transparent electrode 107) and the electron-emitting element 105. The supporting member is indispensable for simplification, miniaturization, and weight reduction of the entire device, since an electron beam display device having a larger display surface is subjected to a larger total atmospheric pressure.

However, in conventional electron beam display devices mentioned above, as shown in Figs. 35 and 36, have a supporting member 110 made of an insulating material, which will be electrified at the surface by undesired collision of electrons and ions thereto. The electrification of the supporting member causes the problems as below: (1) The electron beam is deflected owing to the electrification, whereby the quantity of irradiation of electron beam onto the desired fluorescent material in the picture elements fluctuates to cause irregularity in luminance and color. In particular, when the quantity of the electrification is large, the electron beam is not projected to the desired fluorescent material but is directed to undesired adjacent fluorescent material to cause crosstalk; (2) The quantity of electrification varies with lapse of time, which causes time-variation of the electron path, resulting in variation in the intensity of the luminance; and (3) Electric discharge occurs at the electrified supporting member, which may damage the electron-emitting element or deteriorate the insulating property of the supporting member.

For preventing the above electrification of the supporting member by the electron beam, for example, the insulating material portion of the supporting member 110 is surrounded with a metal cover 113 as shown in Fig. 37 (sectional view). (Japanese Patent Application Laid-Open No. 64-41150). In Fig. 37, the metal cover 113 is fixed by a member 114 at the supporting member 110. The metal cover 113 is connected electrically to a transparent electrode 107. Thereby, the metal cover 113 is kept at the same voltage as the transparent electrode (fluorescent material 108). Generally, the transparent electrode 107 is kept at a high potential so as to capture the electron beam. When the metal cover is kept at a high potential is placed in proximity to the electron-emitting element 105, the electron beam emitted from the electron-emitting element 105 is deflected toward the side of the metal cover 113, causing different problems mentioned below: (4) A fraction of the electron beam is captured by the metal cover, whereby the intensity of the electron beam is lowered and the luminance of the fluorescent material is lowered at the proximity to the supporting member, causing irregularity of the luminance; and (5) The potential applied to the transparent electrode (fluorescent material) can-

supporting member. In such a case, the applied voltage is preferably not higher than 0 V (not higher than the potential of the lower potential electrode of the electron-emitting element) as is clear from the results of the above investigation.

Other construction members of an image-forming member of the present invention are described below in detail.

The electron-emitting element may be either a hot cathode or a cold cathode which are employed in conventional image-forming devices. However, with the hot cathode, the electron emitting efficiency and the response rate will decrease owing to diffusion of heat to the substrate supporting the cathode. Furthermore, the image-forming member may deteriorate by action of heat. Therefore, the density of arrangement of the hot cathodes and the image-forming members is limited. From the consideration above, as the electron-emitting element, preferred are cold cathodes including surface conduction type emitting elements as described below, semiconductor type electron-emitting elements, and field emitting elements. From among these cold electrodes, particularly preferred are the surface conduction type emitting elements because of the advantages such as: (1) high electron-emitting efficiency, (2) ease of production of the element and high density of arrangement of the elements on a substrate because of the simple element structure; (3) high response rate; and (4) excellent contrast of luminance.

An example of the surface conduction type emitting elements is the cold cathode element disclosed by M.I. Elinson, et al. (Radio Eng. Electron Phys., Vol. 10, pp. 1290-1296 (1965). This element, generally called a surface conduction type electron-emitting element, utilizes electron emission phenomenon caused by an electric current flowing in a thin film formed in a small area on a substrate in a direction parallel to the thin film. The surface conduction type electron-emitting element includes those utilizing a thin film of SnO_2 developed by Elinson et al. (loc. cit), those utilizing a thin film of Au (G. Dittmer: "Thin Solid Films", Vol. 9, p. 317 (1972)), and those utilizing a thin film of ITO (M. Hartwell and C.G. Fonstad: "IEEE Trans. ED Conf." p. 519 (1983).

The typical construction of such a surface conduction type electron-emitting element is illustrated in Fig 8. The element comprises electrodes 51a and 51b for electric connection, a thin film 52 formed from an electron-emitting material, a substrate 54, and an electron-emitting section 53. In preparation of such a surface conduction electron-emitting element, an electron-emitting section is formed by electric heating treatment called a forming treatment before the use for the electron emission. In the forming treatment, a voltage is applied between the electrode 51a and the electrode 51b to flow electric current through the thin film 52, thereby the thin film 52 being locally destroyed, deformed, or destroyed by generated Joule's heat to form an electron-emitting section 53 in a high electric resistance state. Thus electron-emitting function is attained. Here, the "high electric resistance state" means a discontinuous state of the film that a crack of 0.5 µm to 5 µm long having an "island structure" is formed in a portion of the thin film 52. The island structure means generally a state of the film that fine particles of some tens of angstroms to several micron meters in diameter are disposed on a substrate and the particles are spacially discontinuous mutually but are electrically continuous. Conventional surface conduction type electron-emitting elements emit electrons from the above fine particles on application of voltage to the above high-resistance discontinuous film through the electrodes 51a and 51b to flow electric current on the surface of the elements

The inventors of the present invention disclosed in U.S. Patent No. 5,066,883 a novel surface conduction type electron-emitting element in which particles to emit electrons are scattered between the electrodes. This electron-emitting element is advantageously capable of giving higher electron-emitting efficiency than conventional surface conduction type emitting elements. Fig. 9 illustrates typical construction of the element. The element comprises electrodes 51a and 51b for electrical connection, a thin film (an electron-emitting section) 55 on which fine particles 56 of a size of 10 Å to 10 µm are scattered, and an insulating planar substrate 54. In particular, in Fig. 9, the thin film 55 has preferably a sheet resistance in a range of from 10^3 Ω/square to 10^9 Ω/square, and electrode interval in a range of from 0.01 µm to 100 µm.

As discussed above, various types of electron-emitting elements are useful in the present invention. Among them, the cold cathodes involve the notable disadvantages of decrease of electron-emitting efficiency, and crosstalk: cold cathodes such as surface conduction type emitting elements and field emitting elements in which initial velocity of emitted electrons are large; in particular, electron-emitting elements in which the initial velocity of emitted electrons is in a range of from 4.0 eV to 200 eV, and the electron beam is deflected from the perpendicular direction toward a high resistance electrode side because the electrons in a beam emitted from an electron-emitting section have velocity component directing to the high resistance electrode on application of a voltage. Hence, the technique of control of the potential of the supporting member according to the present invention is significantly effective in the image-

forming device employing the above electron-emitting elements.

The image-forming member in the present invention may be made from any material which, on irradiation of electron-beam emitted for the electron-emitting element, causes luminescence, color change, electrification, denaturing, deformation, or a like change. The example of the material includes fluorescent materials and resist materials. In the case where fluorescent material are used, the image formed is a luminescent image or a fluorescent image, and for formation of full-color luminescent image the image-forming member is formed from luminescent materials of three primary colors of red, green, and blue.

The electron-emitting element and the image-forming member are arranged in such manners as: (A) the electron-emitting elements 5 and the image-forming member 8 as shown in Fig. 1 are respectively disposed on counterposed substrate faces 6 and 1 in an envelope; or (B) the electron-emitting elements 75 and the image-forming member 78 are disposed on the one and the same face of the substrate 71 as shown in Fig. 17. In the case of (B), since the positive ions generated by collision of emitted electrons collide less against the residual gas in the envelope, deterioration of the electron-emitting element is remarkably prevented, thereby giving longer life of the electron-emitting elements than in the case of (A). Furthermore, the arrangement as in the case of (B) is preferred particularly for the electron-emitting elements in which the electron beam is deflected from the perpendicular direction toward the high resistance electrode as in the case of surface conduction type emitting elements and field emitting elements.

The supporting member in the present invention may be a member constituted of an electroconductive material, or an insulating member such as glass which is coated with an electroconductive material. Otherwise the supporting member may be an insulating material on which electroconductivity is imparted partially. In this case, the electroconductivity-imparted region is placed in vicinity to the electron-emitting section of the electron-emitting element. Further, in the present invention, the supporting members can be arranged on any pattern provided they are capable of maintaining the envelope against atmospheric pressure. Consequently, it is not necessary for them to be stationed at every electron-emitting sections.

In a case where an electron beam emitted from the electron-emitting element is modulated in accordance with an information signal (control of the quantity of emitted electrons, including on-off control of electron emission), a modulation means is additionally provided. Such a modulation means includes: (I) means in which voltage is applied in accordance with an image information signal to a modulation electrode 18a placed on the same plane of the substrate 1 as an electron-emitting element 5 as shown in Fig. 11, or a modulation electrode 60 formed by lamination on an electron-emitting element 5 with interposition of an insulating layer 62 as shown in Fig. 15 to form a desired potential plane in vicinity to the electron-emitting section, thereby controlling the quantity of electron emission; and (II) means in which potential is applied in accordance with image information signals to scanning electrodes 2a and information signal electrodes 2b arranged in an XY matrix and connected to respective electron-emitting sections 4 arranged also in an XY matrix.

The above constituting members are placed in the envelope. The inside of the envelope is kept at a vacuum degree in a range of from 10^{-5} to 10^{-9} torr in view of the electron emission characteristics of the electron-emitting elements. The aforementioned supporting member is placed so as to support sufficiently the envelope against the external atmospheric pressure, the shape, the arrangement, and the position being suitably decided.

The image-forming device of the present invention includes the optical printers described below.

As shown in Figs. 31 to 33, the optical printer of the present invention employs, as a light source 83, the above image-forming member of the above image-forming device formed by luminescent material. A luminescent pattern is formed in accordance with information signals as described above, and the light beam emitted from the luminescent material in accordance with the luminescent pattern is projected to a recording medium (86, 88, 89) to form an optical pattern if the recording medium is a photosensitive material, or a thermal pattern if the recording medium is a heat-sensitive material. The optical printer has a support (e.g., a drum 87, and a delivering rollers 85) for supporting or delivering the recording medium. The recording medium may be a photosensitive drum 89 as shown in Fig. 33.

The present invention is described specifically and in more detail by reference to Embodiments.

Embodiment 1

Fig. 1 illustrates a rough perspective view of an image-forming device of a first embodiment of the present invention. Fig. 2 is a cross-sectional view of the image-forming device viewed at A-A' in Fig. 1.

In the drawing, a rear plate 1, an external frame 11, and a face plate 9 constitute an envelope. An electron-emitting section 4, and electrodes 3a and 3b for applying voltage to the electron-emitting section constitute an electron-emitting element 5. Wiring electrodes 2a and 2b (7a: a scanning elec-

trode, and 7b: an information signal electrode) are connected respectively to the above electrodes 3a and 3b. A glass substrate 6, a fluorescent material (image-forming member) 8, and a transparent electrode 7 for applying voltage to the fluorescent material constitute the face plate 9. The numeral 12 denotes a luminescent spot, the numeral 10 denotes an electroconductive supporting member to support the envelope against external atmospheric pressure, and the numeral 13 denotes a power source for applying prescribed voltage to the electroconductive supporting member.

As shown in the drawing, the electron-emitting element 5 and the fluorescent material 8 as the image-forming member are placed respectively on a counterposed substrates (a rear plate 1 and a glass plate 6). The electroconductive supporting member 10 is placed between the substrates so as to support the rear plate 1 and the face plate 9 against the atmospheric pressure. As shown in Fig. 2, the supporting member 10 is positioned between the electron-emitting elements 5 on the rear plate side, and is positioned on the face plate side without electrical contact with the fluorescent materials 8 and the transparent electrode 7, so that the potential of the supporting member 10 is decided certainly by the potential applied by the power source 13.

The electron-emitting element 5 is the aforementioned surface conduction type emitting element. A plurality of electron-emitting elements are arranged in an XY matrix. All of the electrodes 3a of the electron-emitting elements are connected to the scanning electrodes 2a. The electrodes 3b are connected to the information signal electrodes 2b. Thus the electron-emitting element has a simple matrix construction which emits electrons on application of voltage between the electrodes 2a and 2b in corresponding with information signals.

The transparent electrode 7 constructing the face plate 9 is connected to an external power source although it is not shown in the drawing. Therefore a prescribed voltage is applied through the transparent electrode 7 to the fluorescent material 8 placed in adjacent to the transparent electrode 7. This voltage is usually in the range of from 800 V to 6 kV, but is not limited thereto. In the case where a color image is displayed, the fluorescent material 8 is replaced with a three-primary color fluorescent materials of red, green, and blue.

A process for producing an image-forming device of this Embodiment is briefly described below.

(1) An insulating substrate, as a rear plate 1, is sufficiently washed. Thereon electrodes 3a, 3b are formed according to conventional vapor deposition technique and photolithography technique. Subsequently an information electrodes 2b is formed similarly.

(2) For electrical insulation of an information signal electrode 2b from a scanning electrode 2a, an insulating layer is formed at the site where the electrodes will intersect (not shown in the drawing). Then a scanning electrode 2a is provided according to a vapor deposition technique and a patterning technique (including photolithography and etching).

In the above steps (1) and (2), the electrodes are formed with a material mainly composed of nickel, gold, aluminum, or the like to have sufficiently low electric resistance. The insulating layer is formed mainly from SiO_2, or the like. In surface conduction type emitting elements, the gap G between the electrodes 3a and 3b (electrode gap) is preferably in a range of from 0.01 µm to 100 µm, more preferably from 0.1 µm to 10 µm in view of the electron-emitting efficiency. In this Embodiment, the gap is 2 µm, the length L of the electron-emitting section 4 is 300 µm, and the arrangement pitch of the electron-emitting elements 5 is 1.2 mm.

(3) Then an ultrafine Pd particle film having particle diameter of about 100 Å is formed between the opposing electrodes 3a and 3b. As the material for the ultrafine particle film, suitable are metals such as Ag and Au, and oxides such as SnO_2 and In_2O_3 in addition to the above-mentioned Pd. In surface conduction type emitting elements, the particle diameter is preferably in a range of from 10 Å to 10 µm especially in view of the electron-emitting efficiency. The ultrafine particle film is adjusted to have a sheet resistance preferably in a range of from 10^3 Ω/square to 10^9 Ω/square. The ultrafine particle film having desirable characteristics can be prepared, for example, by applying a dispersion of an organometal and heat-treating the applied organometal to form an ultrafine particle film between the electrodes, instead of gas deposition method mentioned above.

(4) Then, on a glass substrate 6, a transparent electrode 7 is formed with a material of ITO according to conventional technique of vacuum deposition and patterning, and thereon a fluorescent material 8 is laminated, thus completing a face plate 9.

(5) An electroconductive supporting member 10 is placed as shown in Fig. 2. The electroconductive supporting member employed here is prepared by working photosensitive glass 10a and providing an electroconductive film 10b on the surface thereof. The electroconductive support has a thickness T_2 of 150 µm, a height T_1 of 1500 µm.

(6) An external frame 11 of 1.5 mm thick is placed between rear plate 1 and the the face plate 9. Then frit glass is applied between the

7/1

FIG. 1